[0046] In the simplest case, a touch event T is initiated each time an object, such as a user's finger, is placed on upper surface **126** over, or in close proximity to, sensing region **128**. Pressure generated by touch event T is transmitted through protective layer **120** at sensing region **128** to sensing device **124**. In response to the pressure applied by the user during touch event T, sensing device **124** generates touch signal S_1 (and any other signal consistent with a multi-touch event). Touch signal S_1 can be monitored by an electronic interface (not shown) and passed to processor **106**. Processor **106**, in turn, can convert the number, combination and frequency of the signal(s) S into touch information T_{info} that can include location, direction, speed and acceleration information of touch event T. Processor **106** can then pass touch information T_{info} to micro-controller **132**. Although micro-controller **132** is shown as a component separate from processor **106**, it is contemplated that functions carried out by micro-controller **132** can in fact be performed by processor **106**.

[0047] Micro-controller **132** can use touch information T_{info} to query haptic data base **134** that includes a number of pre-determined haptic profiles each of which describes a specific haptic response H_x in terms of duration of response, type of vibro-tactile response, strength of response, etc. A particular haptic profile includes a set of instructions that cause microcontroller **132** to activate at least haptic actuator **136**. Haptic actuator **136**, in turn, creates haptic response H_x. In this way, the response of haptic actuator **136** can be controlled in real time by microprocessor **132** by establishing the duration, strength, type of vibro-tactile response H_x. Furthermore, the visual information presented on display **112** and the corresponding tactile response can be closely linked. For example, if the location of touch event T coincides with a visual display of a button icon generated by display device **112**, the corresponding haptic response provided by haptic actuator **136** can have a haptic profile H_{button} consistent with that of a dome button.

[0048] In some embodiments it may be desirable to associate each sensing node **128** with one or more corresponding haptic actuators. For example, sensing node **128** can trigger haptic actuator **136** and/or **140** or even **142** independent of each other or in concert. Accordingly, sensing nodes **128** can be arranged in such a way as two or more haptic actuators can cooperate to produce a compound haptic effect. It should be noted that an effective range R (distance over which a particular haptic actuator can be felt) for each of the haptic actuators can be based upon many factors such as intrinsic nature of the haptic actuator (i.e., mechanical vs EPAM), the damping properties of protective layer **120**, the harmonic frequency of the device **100**, and so on.

[0049] As shown in FIGS. **1C-1E**, touch event T can result in multiple haptic actuators **136** being activated each being driven by a separate set of instructions based upon different haptic profiles. For example, as shown in FIG. **1C**, haptic actuator **136** can respond with haptic effect H_1 whereas haptic actuator **140** can respond with haptic effect H_2 (or H_1 for that matter). In some cases as shown in FIG. **1D**, a compound haptic effect $H_{compound}$ can be generated by providing the same or different haptic profiles to at least two different haptic actuators which interfere with each other (either constructively or destructively) to form compound haptic effect $H_{compound}$. Still further, as shown in FIG. **1E**, due to the fact that housing **102** and user interface **110** are acoustically isolated from each other, haptic actuator **142** can be used to provide a haptic response directed at housing **102** independent of any haptic response or responses directed at user interface **110**. For example, touch event T can cause processor **106** to direct microcontroller **132** to instruct haptic actuator **142** to produce haptic effect $H_{housing}$ (such as vibrate housing **102**) at the same time as instructing haptic actuators **136** (and/or **140**) to generate a haptic response H_1 and/or H_2. In this way, a user will feel housing **102** vibrate independent of any tactile response emanating from display interface **110** (and more particularly protective layer **120**) thereby increasing the amount and variety of information that can be provided to (and by) the user. In this way, user interface **110** using display device **112** and haptic actuator **136** can provide both visual and tactile information to the user.

[0050] It should be noted that haptic actuator **136** can be formed as a small and thin chip and thus can be installed into the mobile apparatus such as small form factor/handheld devices such as cell phones, media players, and the like and can be electro-polymer based, piezo-electric based, or any combination thereof. In this way, user interface **110** using display device **112** and haptic actuator **136** can provide both visual and tactile information to the user. Furthermore, the components of the device **100** can be chosen to provide more effective haptic sensations. For example, if haptic actuator **136** oscillates at close to a natural frequency of the mechanical system (including the actuator itself), then stronger forces and more effective haptic sensations can be output. Accordingly, the mass (as well as the spring constants of the system **100**) can be selected to provide a desirable low natural frequency, such as about 120 Hz or less, which tends to cause effective haptic sensations. It should also be noted that multiple haptic actuators can be driven in unison for stronger haptic effects or at different times to provide sensations at particular locations of surface **126**.

[0051] One of the advantages of the invention lies in the fact that the relationship between a touch event or a class of touch events and corresponding haptic response can be dynamic in nature. By dynamic it is meant that although specific haptic profiles H stored in haptic profile data base **134** remain static, the haptic profile (or profiles) used to respond to a particular touch event T can be varied based upon any number of factors. For example, if touch event T coincides with a particular GUI icon displayed by display device **112** (such as the button icon described above), the corresponding haptic response H_x can vary depending upon not only the icon displayed but also the location on surface **126** of touch event T (i.e., T(x)), any finger motion ($\partial T/\partial x, \partial T/\partial y$), any pattern of lifting a finger and placing it back down on surface **126** (i.e., ($\Delta T/\Delta t$) such as multiple clicks in the case of a button icon, and so on. For example, vibrations can be adjusted based on a change in touch characteristics (i.e., speed, direction, location, etc.) whereas different vibrations can signify different events or regions. Furthermore, vibrations can be mapped to animation effects occurring on display **112** (rubber band, bounce etc.) or be based on location in the form of an intensity map on the surface **126**.

[0052] Haptic actuators associated with system **100** can be arranged in groups. For example, one such group can include a primary haptic actuator arranged to provide a vibro-tactile response and at least one secondary device selected from piezo-ceramic element or EPAM arranged to provide another type response. In this way, the primary haptic actuator can be utilized to convey a status (e.g., incoming call) as well as passive responses to touch events such as location of input areas (e.g., virtual buttons) while the secondary device can be